

Subrecent Intertidal Diatoms from St. Catherines Island, Georgia: Taphonomic Implications

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ABSTRACT



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The taphonomic overprinting of diatom assemblages has been underemphasized in paleoecological studies. Subrecent (< 700 YBP) cohesive muds, interpreted on the basis of previous macrofloral and macrofaunal evidence as intertidal salt marsh deposits, are exposed on Middle Beach, St. Catherines Island, Georgia. Analysis of nine diatom-bearing sediment samples from a 1.2 meter section yielded a total of 79 species representing 34 planktic and benthic genera. Depth vs percentage plots for selected taxa yielded no clear-cut ecological zonation among the diatom assemblages. Diatoms from all samples display strong diagenetic and taphonomic overprinting. Delicate benthic taxa reported to be living in the marshes on Sapelo Island, to the south, are either absent, rare, or severely altered in the relict marsh muds of St. Catherines Island, most likely due to fragmentation and dissolution. As a result, the most abundant species, *Cymatosira belgica*, although rare in modern salt marsh environments, has been proportionally enriched. This species accounts for up to 75% of the diatom individuals in the upper third of the section and approximately 50% at greater depths. Fragmentation and dissolution can alter a salt marsh diatom assemblage so drastically that the end product does not even resemble the initial living flora. In the interpretation of temporal sequences of littoral diatoms, taphonomic intensity has to be considered in terms of possible selective removal of certain key taxa. Taphonomic processes can mask the original ecologic relationships that exist in a salt marsh flora, and result in proportional over-representation of resistant species (e.g. *Cymatosira belgica*) confounding paleoecologic and paleogeographic reconstructions.

ADDITIONAL INDEX WORDS: *Diatom assemblages, salt marsh benthic taxa, littoral diatoms, estuary diatoms, taphonomy, relict marsh deposits, barrier island.*

INTRODUCTION

Researchers conducting estuarine research are becoming increasingly aware of the value of long-term biological data sets (WOLFE *et al.*, 1987) and are starting to appreciate how fossil assemblage data can provide important information of community structure, unimpeded by short-term ecological "noise" (STAFF *et al.*, 1986; CARTHEW and BOSENCE, 1986; KIDWELL and BEHRENSMEYER, 1988). Such information is difficult to acquire, however, and can only result from careful assessment of how time-averaging and taphonomy act upon living organism associations.

Diatoms from coastal salt marsh deposits of the United States have not been extensively studied. No studies, to date, have focused on the diatom assemblages of the relict salt marsh

deposits located on the barrier islands along the coast of Georgia. HUSTEDT (1955) examined and described the diatom assemblages from muds exposed on the beach at Beaufort, North Carolina, but did not address problems associated with the taphonomic accumulation of the assemblage. BURKLE (1978) suggested that associations of benthic marine and brackish water diatoms may be useful in paleoecologic reconstructions of nearshore environments and documentation of past sea level changes.

Most salt marsh diatom studies have focused on the living diatom communities (SULLIVAN, 1975, 1977; RIZNYK, 1973; DARLEY *et al.*, 1979; KENNETT and HARGRAVES, 1985). However, a few workers have addressed the significance of allochthonous valves in estuarine deposits (GERLACH and HOHNK, 1969; BEYENS and DENYS, 1982; VOS and DEWOLF, 1988). WILSON and HOLMES (1981) suggested that a portion of the diatom death

assemblage in an estuarine environment is probably allochthonous and thus represents a spatial and temporal mixture of diatom valves. They recommended that only the living association be used to characterize the salt marsh assemblage. Living diatom associations are, however, notoriously ephemeral and may bear very little similarity to the time-averaged and taphonomically overprinted death assemblages. ANDREWS (1972) and ANDREWS and ABBOTT (1985), impressed by preservational differences among species, considered quantitative studies of diatom assemblages inappropriate. They were particularly concerned with original skeletal construction (especially weakly silicified *vs.* robust species), predepositional breakage, and compaction.

The goals of this study are to: (1) document the diatom assemblages within a stratigraphic interval of relict intertidal salt marsh muds exposed along the oceanward side of St. Catherines Island, Georgia (2) assess the effects of time-averaging and taphonomy upon the diatom assemblages, and (3) evaluate the use of such diatom assemblages for reconstruction of ancient coastal environments.

GEOLOGIC SETTING

St. Catherines Island is about 64 km south of Savannah, Georgia, in approximately the center of the Georgia Bight (Figure 1). About 8 km of salt marsh separate the island from the mainland of Georgia. St. Catherines Island, about 16 km long and 3.2 km wide, is a beach-ridge type of island (ZEIGLER, 1959), consisting of a barrier-remnant Pleistocene core sporadically bordered by Holocene beach ridges (OERTEL, 1975; HOWARD and FREY, 1980, 1985; FIERSTIEN and ROLLINS, 1987; KENNEDY and PINKOSKI, 1987). Approximately two-thirds of the island's area formed during the Holocene by deposition of beach ridges and tidal marshes on the oceanward side (DEPRATTER and HOWARD, 1977). *Spartina* marshes comprise about 80% of the western shoreline of the island, as well as much of the east-central portion, and a barrier beach extends along the entire eastern margin, broken only by Seaside and McQueens Inlets (Figure 1B; FIERSTIEN and ROLLINS, 1987).

The intertidal environments of St. Catherines Island have been discussed by FIERSTIEN

and ROLLINS (1987) and consist of sandy beaches, tidal mud flats, salt marshes, and relict salt marshes. Intertidal macroinvertebrate associations of St. Catherines Island were studied by MORRIS and ROLLINS (1977) and FIERSTIEN and ROLLINS (1987). KENNEDY and PINKOSKI (1987) discussed aspects of sand transport and source. The relict marsh deposits of St. Catherines Island were studied by MORRIS and ROLLINS (1977) and PEMBERTON and FREY (1985), and the limited number of available radiocarbon dates (plant and shell material) suggests that these deposits are no older than 5-6,000 years BP, the approximate date of late Holocene stabilization of sea level in this region (PEMBERTON and FREY, 1985).

The intertidal environments and habitats of St. Catherines Island are very similar to those of Sapelo Island, to the south. The latter have been extensively studied for several decades by many researchers and excellent summary reviews and literature compilations can be found in BASAN and FREY (1977); HOWARD and FREY (1980); FREY and BASAN (1981); PEMBERTON and FREY (1985); HOWARD and FREY (1985).

This study focuses upon the relict marsh muds exposed along Middle Beach (Figure 1B). This portion of the island is extensively wave-eroded and surge channels in the relict marsh deposits expose vertical sections up to 1.5 m deep (Figures 3A, 3B). A living salt marsh is situated immediately to the west, protected by barrier dunes.

METHODS

Sample Collection

The nine bulk samples analyzed for diatom content were obtained by excavating a 1.2 m deep pit in the relict marsh sediments of Middle Beach, just south of Seaside Inlet (Figures 3A, 3B). Samples were taken at 5 cm intervals along a vertical section extending from the erosional upper surface to the base of the pit. After perusal of sedimentologic and biologic characteristics, samples were grouped into three stratigraphic units. Selected samples from these stratigraphic units were used for detailed diatom analysis.

Several surface samples were collected from the living marsh immediately west of Middle

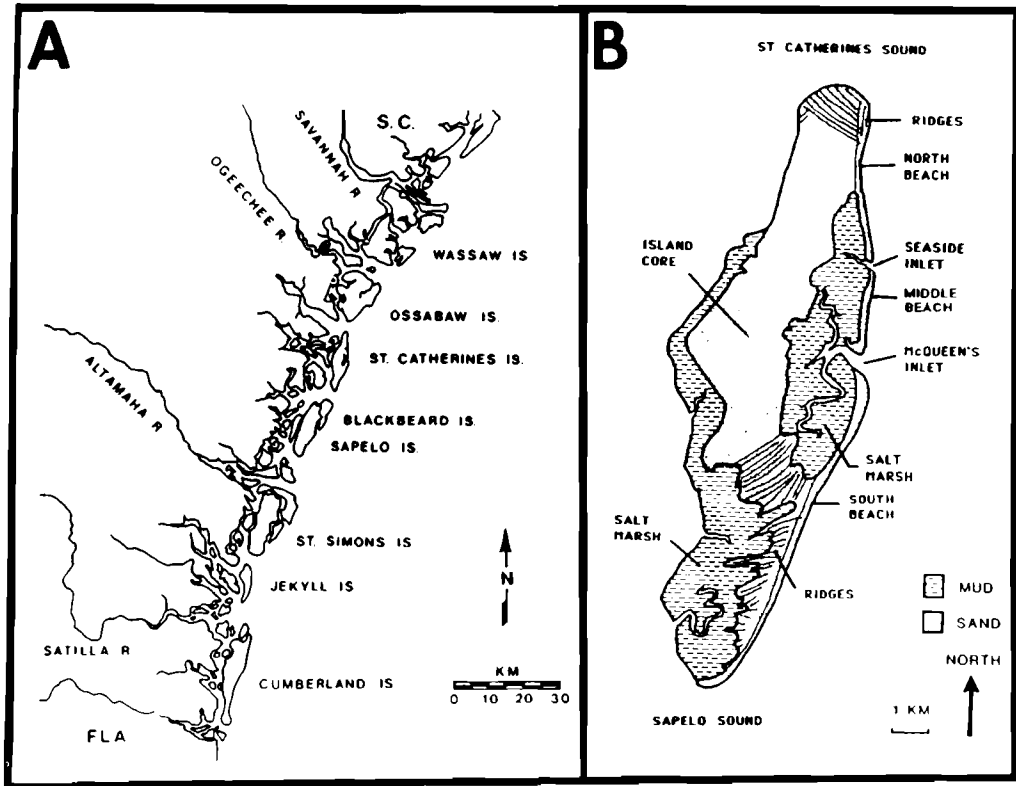


Figure 1. Maps showing: (A) location of St. Catherines Island along the Georgia Coast and (B) features of the island. Sample area is on Middle Beach south of Seaside Inlet.

Beach. These samples were retrieved using small hand corers (2.5 cm diameter), and the top 1 cm of mud was removed, placed in a plastic bag, and labeled.

Particle Size Analysis

In order to estimate the relative percentages of sand, silt, and clay, particle size analysis was performed on eight splits taken from the bulk samples. Each sample split was air-dried at room temperature and disaggregated. The sample was then passed through a series of three sieves: .125 mm (3 phi), .088 mm (3.5 phi), and .063 mm (4 phi). Sediment grains smaller than 4 phi were collected in a pan at the base of the sieve stack. Samples taken from the uppermost portion of the relict marsh section were not sieved because they contained a high percentage of organic material.

Diatom Analysis

A total of 9 stratigraphic samples and 2 surface samples were analyzed for diatom content (see Figure 2 for stratigraphic distribution of samples). The sediment splits (1-2 cc each) utilized for diatom analysis were prepared according to the procedures discussed by ABBOTT and ERNISSEE (1983). This involved removal of carbonates and salts with hydrochloric acid, removal of organics with hydrogen peroxide, and removal of clays by differential settling and decanting. The resulting diatom-rich material was placed in a glass vial with approximately 20 ml distilled water, resuspended, and 2 or 3 drops were removed with a pipette and positioned in the center of a glass cover slip. The water was allowed to evaporate and the cover slip was then inverted in Naphrax and cured for 5 minutes at approximately 150 degrees C.

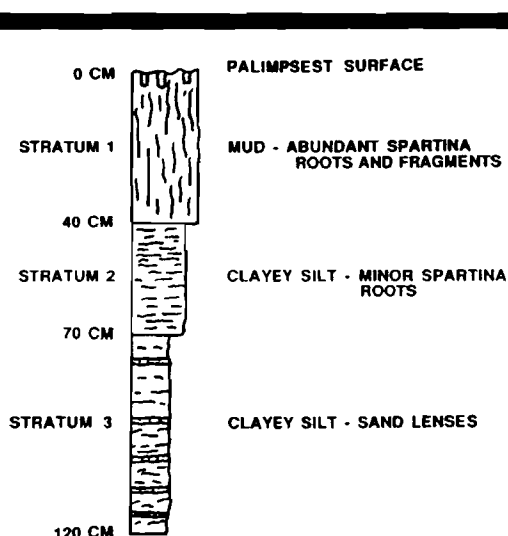


Figure 2. Generalized stratigraphic section of Middle Beach sample site.

Diatoms were identified and counted under 1000X magnification. For each stratigraphic sample 500 diatom valves were counted and relative species percentages were calculated. Each modern surface slide was examined in order to ascertain any differences between the living diatom assemblage and those in the stratigraphic section. Fragments smaller than one-half a complete valve were not counted. Frequency distribution vs. depth for selected taxa is presented in Figure 4. Species identifications followed those of HUSTEDT (1955), BOYER (1926, 1927), GRUNOW (1862, 1860), ANDREWS (1972, 1974), RIZNYK (1973), ABBOTT and ANDREWS (1979), DEXIANG *et al.* (1979), and ANDREWS and ABBOTT (1985).

RESULTS

Stratigraphy

The generalized stratigraphy of the Middle Beach sampling site is presented in Figure 2. Three distinct units were recognized; an upper green-gray cohesive mud containing abundant *Spartina alterniflora* roots and fragments, a middle gray clayey silt, and a lower gray clayey silt with thin sand lenses increasing in abundance toward the base of the unit. Sand-sized grains wherever present are mainly quartz. The

mineralogical composition of the clay-sized particles was not determined.

The stratigraphic interval at Middle Beach is very similar to those described from other exposures within the Georgia Bight (BASAN and FREY, 1977; MORRIS and ROLLINS, 1977; FREY and BASAN, 1978, 1981; PEMBERTON and FREY, 1985)

Stratum 1. The upper stratigraphic unit at the Middle Beach sample site is about 40 cm thick, and is a massively-bedded mud with abundant fragments of *Spartina alterniflora* roots and stem fragments. The top of the unit is an erosional palimpsest surface referable to the *Glossifungites* ichnofacies (PEMBERTON and FREY, 1985). Several species of marine bivalves currently utilize the firm substrate of relict marsh mud, either by burrowing (*e.g. Petricola pholadiformis*) or by epibenthic byssal attachment (*e.g. Brachidontes recurvus*) (MORRIS and ROLLINS, 1977; PEMBERTON and FREY, 1985). Stratum 1, as indicated by the presence of abundant fragments of *Spartina alterniflora*, and shells of *Littorina irrorata*, *Ilyanassa obsoleta*, and *Geukensia demissa*, clearly represents deposition in a low marsh setting and is very similar to other low marsh deposits described from Cabretta beach, Sapelo Island (HOWARD and FREY, 1980; PEMBERTON and FREY, 1985) and Petit Chou Island (PEMBERTON and FREY, 1985).

Stratum 2. This unit extends from about 40 cm to 70 cm below the surface and consists of massively-bedded clayey silts which contain only minor amounts of *Spartina alterniflora* fragments. The unit has been extensively bioturbated by both roots and burrowing organisms, and exhibits few laminations. Sparse shell fragments of typical marsh macro-invertebrates were observed. We infer that this unit was deposited in a low marsh environment, as well.

Stratum 3. The stratigraphic interval from 70 cm to the base of the excavated section (120 cm) is predominantly a clayey silt with numerous thin sand lenses, more closely spaced and thicker toward the base. *Spartina* fragments and shell fragments of marsh macro-invertebrates are present, but rare. This unit may reflect deposition in a former tidal creek chan-

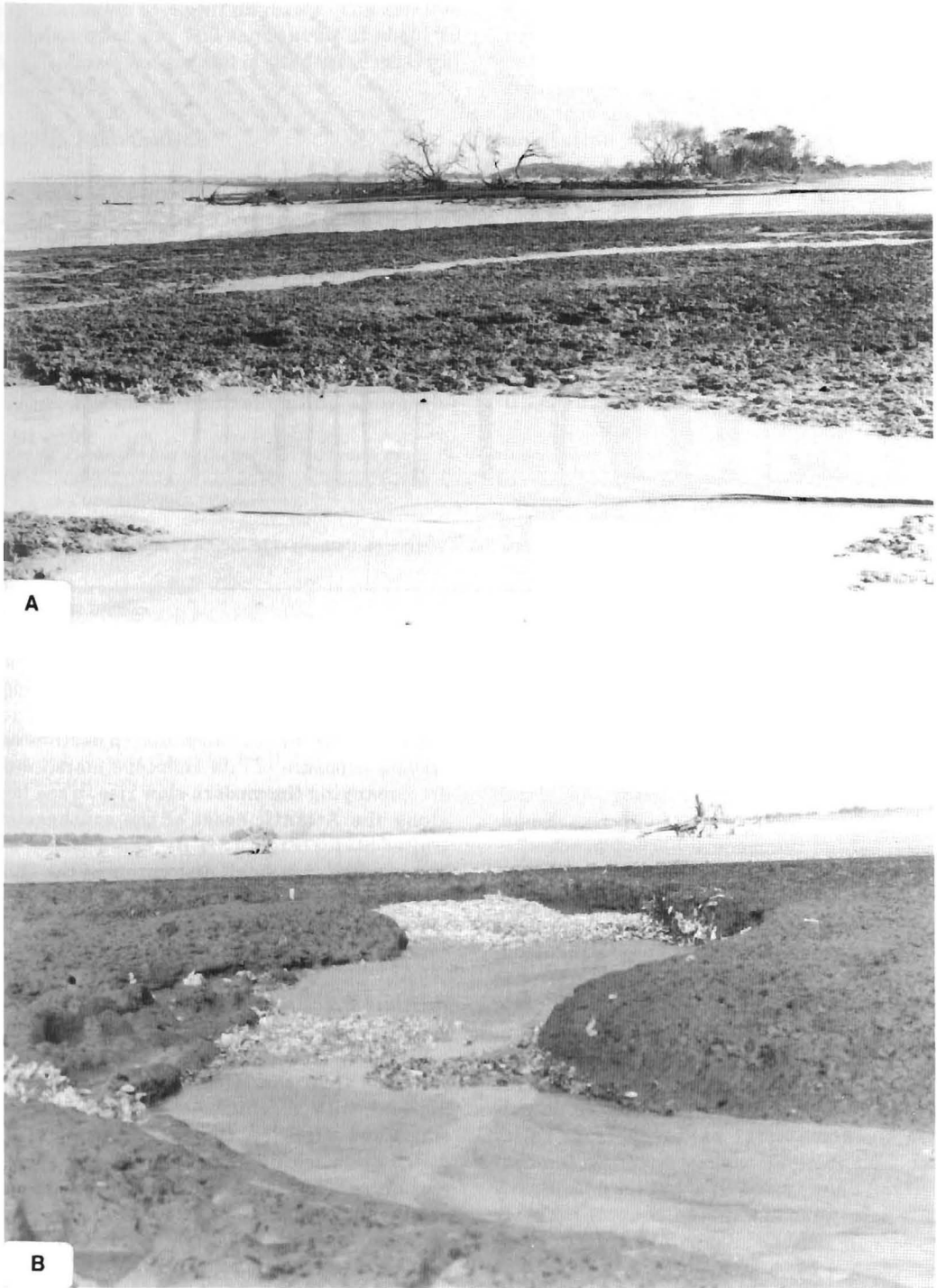


Figure 3. Relict marsh sediments exposed along Middle Beach, St. Catherines Island, Georgia. (A) View to the south at low tide showing the extent of relict marsh exposure. (B) View to the west at low tide showing exposure of relict marsh sediments in a tidal scour channel. Living salt marsh is behind barrier beach in background.

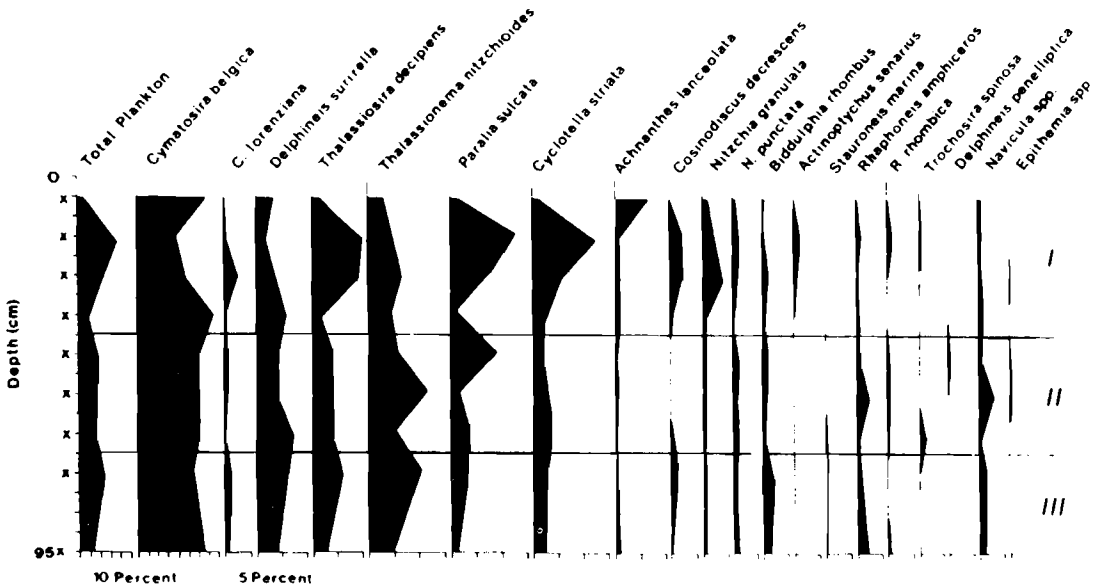


Figure 4. Distribution of diatom species with depth, Middle Beach section, St. Catherines Island. "X's" mark positions of diatom samples and roman numerals denote stratigraphic intervals.

nel or in a sparsely vegetated salt marsh flat adjacent to the inner side of a barrier beach complex. In the latter case, the sand lenses might represent the distal tapering edges of overwash deposits. Such overwash deposits presently interfinger with a living low marsh about 100 meters west of the Middle Beach sample site, behind the modern barrier beach.

Age of Relict Marsh Deposits. The relict marsh deposits exposed on the oceanward sides of the Georgia sea islands are generally considered to reflect eastward growth of salt marshes concomitant with (and subsequent to) the late Holocene lowstand of sea level in the area, approximately 4500 to 2400 BP (DEPRATTER and HOWARD, 1981; PEMBERTON and FREY, 1985). A single radiocarbon date taken on palmetto wood material exhumed from relict marsh mud about 30 m south and only few centimeters below the base of the Middle Beach sample site indicated an age of approximately 700 years BP. PEMBERTON and FREY (1985) reported that the upper portion of the relict marsh deposits at North Beach (station 1 of MORRIS and ROLLINS, 1977) dated at 475 years BP and a sample about 0.5 m lower pro-

vided a date of 1325 years BP. This North Beach station is only about 3 km north of the Middle Beach sample site.

The Middle Beach relict marsh section represents exposure of late Holocene marsh muds accompanying the modern slow rise in sea level along the Atlantic coast of the southeastern United States (Figure 3A, B). This sea level rise has resulted in a small dislocation of the facies tract mosaic so that the living back barrier marsh has moved a few tens of meters to the west at Middle Beach.

Particle Size Distribution

Particle size distribution within each sample collected from the Middle Beach section was bimodal, with varying proportions of sand and clay sized particles. Changes in particle size distribution within the sampled stratigraphic section coincide with the stratal boundaries, displaying abrupt shifts at 40 cm and at 70 cm depths. This pattern is due to increasing percent sand-sized sediment with depth. Clay-sized particles (<4 phi) comprise up to 58% of the upper 40 cm of sediment. As a depth of 40 cm the amount of clay-sized material begins to

decrease while the abundance of silt and sand-sized particles (3-4 phi) increases. The relative abundances of clay and sand invert at about 70 cm depth and the amount of sand-sized material reaches 50%.

Diatom Distribution

A total of 79 species of diatoms, apportioned among 34 genera, were identified from the Middle Beach relict marsh section (see Table 1). The stratigraphic distribution of selected taxa is presented in Figure 4.

Cymatosira belgica was the most abundantly represented species in the Middle Beach deposits, comprising up to 75% of the total number of diatom specimens and remaining above 50%

through most of the examined section (Figure 4). No significant taxonomic differences were observed between the stratigraphic samples and the modern marsh surface samples. Species represented in the living diatom association also occur in the stratigraphic section. Fragmentation and dissolution appear to have greatly affected the diatom assemblage. Fragments were abundant in all of the analyzed samples and a large number of the fragments originated from the longer, more delicate, diatom taxa (e.g. *Nitzschia* spp., *Thalassiothrix longissima*, *Thalassionema nitzschioides*, *Gyrosigma* spp., and *Pleurosigma* spp). Visual examination of 20 fields of view (at 400X) on each slide yielded approximate percentages of valve fragments versus whole valves. Fragment size

Table 1. Composite List of Diatom Species Middle Beach, St. Catherines Island, Georgia.

<i>Achnanthes laceolata</i> (Breb.) Grunow	<i>N. formenterae</i> Cleve
<i>A. cocconoides</i> Riznyk	<i>N. normalis</i> Hustedt
<i>A. curvirostrum</i> Brun.	<i>N. pennata</i> A. Schmidt
<i>A. tenera</i> Hustedt	<i>N. regularis</i> Hustedt
<i>Actinopterychus senarius</i> Ehr.	<i>N. salinarum</i> Grunow
<i>A. bipunctus</i> Lohman	<i>N. vittata</i> (Cleve) Hustedt
<i>Actinocyclus ehrenbergi</i> Ralfs	<i>Navicula</i> sp. (? = <i>N. litoricola</i>)
<i>A. ellipticus</i> Grunow	<i>Navicula</i> sp.
<i>A. ingens</i> Ratray	<i>Nitzschia punctata</i> Grunow
<i>Amphora tenuissima</i> Hustedt	<i>N. granulata</i> Grunow
<i>A. granulata</i> Greg.	<i>N. grossestriata</i> Hustedt
<i>A. proteus</i> Greg.	<i>N. laevis</i> Hustedt
<i>Biddulphia rhombus</i> (Ehr.) Wm. Smith	<i>N. navicularis</i> (Breb.) Grunow
<i>Cocconeis scutellum</i> Ehr.	<i>N. pseudohybrida</i> Hustedt
<i>Cosinodiscus lineatus</i> Ehr.	<i>N. sigma</i> (Kutz.) Wm. Smith
<i>C. curvulatus</i> Grunow	<i>Opephora</i> sp.
<i>C. decrescens</i> Grunow	<i>Paralia sulcata</i> (Ehr.) Cleve
<i>C. excentricus</i> Ehr.	<i>Pleurosigma</i> sp.
<i>C. nitidus</i> Greg.	<i>Rhaphoneis rhombica</i> (Grunow) Andrews
<i>Cyclotella striata</i> (Kutz.) Grunow	<i>R. amphiceros</i> Ehr.
<i>Cymatosira belgica</i> Grunow	<i>R. elegans</i> (Pantocsek & Grunow) Hanna
<i>C. lorenziana</i> Grunow	<i>R. grossepunctata</i> Hustedt
<i>Delphineis surirella</i> (Ehr.) Andrews	<i>R. obesa</i> Hanna
<i>D. penelliptica</i> Andrews	<i>R. paralis</i> Hanna
<i>Diploneis</i> sp.	<i>R. surirella</i> Hanna
<i>D. bombus</i> Ehr.	<i>Thalassionema nitzschioides</i> Grunow
<i>D. crabbro</i> Ehr.	<i>Thalassiosira decipiens</i> (Grunow) Joerg.
<i>D. interrupta</i> (Kutz.) Cleve	<i>T. baltica</i> (Grunow) Ostenfeld
<i>Dimerogramma minor</i> (Greg.) Ralfs	<i>T. excentrica</i> (Ehr.) Cleve
<i>Epithemia</i> sp.	<i>T. leptopus</i> (Grunow) Hasle & Fryxell
<i>Eunotogramma laeve</i> Grunow	<i>Thalassiothrix</i> sp.
<i>E. marinum</i> (Wm. Smith) Peragallo	<i>Trachyneis aspera</i> (ehr.) Cleve
<i>E. rostratum</i> Hustedt	<i>Triceratium alterans</i> Bailey
<i>Gyrosigma peisonis</i> (Grunow) Hustedt	<i>Triceratium</i> sp.
<i>Melosira granulata</i> (Ehr.) Ralfs	<i>Trochosira spinosa</i> Kitton
<i>Navicula abunda</i> Hustedt	<i>Trybliopterychus</i> sp.
<i>N. apta</i> Hustedt	<i>Seletonema costatum</i> (Grev.) Cleve
<i>N. diversistriata</i> Hustedt	<i>Stauroneis marina</i> Hustedt
<i>N. finmarchica</i> Cleve & Grunow	<i>Synedra tabulata</i> (Ag.) Kutz.
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was generally below 5 microns but was much larger if the fragment was from a large diatom. Percentage of fragments per field of view was approximately 80% to 90% in the upper half of the section, decreasing to about 70% to 75% in the lower half of the section.

Biogenic fragmentation of diatom frustules may contribute significantly to the taphonomy of a diatom assemblage. Grazing zooplankton and various larger invertebrates often ingest diatoms and then excrete fecal pellets consisting primarily of fragmented and whole frustules. Several studies have shown that this process can drastically alter the species composition of a diatom assemblage. GERSONDE and WEFER (1987) demonstrated that significant mechanical breakage can occur in a diatom assemblage, especially among larger diatoms, and that dissolution of diatom valves is enhanced by grazing zooplankton. They concluded that these processes can alter a diatom assemblage to the extent that there will be significant differences between what is being produced in the planktic and benthic habitats and what is incorporated into the sediment. Another study by FERRANTE and PARKER (1977) also determined that diatom frustules are important constituents of zooplankton fecal pellets in Lake Michigan, and that considerable fragmentation of the diatom valves results from this predation. Clearly, biogenic fragmentation of diatom frustules can be an important taphonomic process in both marine and freshwater systems.

Dissolution may have played an important role in taphonomic and diagenetic loss from the diatom assemblage, but no quantitative data regarding the intensity of dissolution are available. However, those diatom species mentioned by DARLEY *et al.* (1979) as the most abundant in salt marshes on Sapelo Island, Georgia were either not observed on Middle Beach (*e.g. Cyclindrotheca spp.*) or were very rare (*e.g. Navicula spp., Gyrosigma spp., and Pleurosigma spp.*). MIKKELSON (1980) noted several morphological changes associated with dissolution of diatom valves and some of these were observed in the St. Catherines Island material. Most noticeable were dissolution controlled fragmentation, enlargement of areolae in centric diatoms, and the separation of margins and girdles.

Depth vs. abundance plots of selected diatom taxa suggested no obvious ecological zonation of

species throughout the stratigraphic section (Figure 4). However, several taxa in stratum 2 display shifts in relative abundance. Increasing in relative abundance in stratum 2 are *Navicula spp., Cyclotella striata, Thalassionema nitzschioides, Rhaphoneis amphiceros, and Rhaphoneis rhombica. Cosinodiscus decrescens, Cymatosira lorenziana, and Nitzschia granulata* decrease in relative abundance through the same interval.

Paralia sulcata, Nitzschia granulata, and Achnanthes lanceolata all exhibit decreases in relative abundance from the top to the base of the section. On the other hand, *Delphineis surriella* and *Rhaphoneis amphiceros* are relatively more abundant in the lower portion of the section.

Several extinct Miocene species also appear in the section. Two of these, *Trochosira spinosa* and *Delphineis penelliptica*, appear throughout the Middle Beach section at various intervals, but are most abundant in stratum 2 (Figure 4).

Diatom diversity (Figure 5) ranges from 26 to 36 species and exhibits only a slight increase with depth.

DISCUSSION

SULLIVAN (1975, 1977) demonstrated an ecological zonation among the living diatom floras of salt marshes. However, the vertical distribution of the diatom flora at Middle Beach does not show any strong relationship between stratigraphic position and ecological zonation. The diatoms recovered from stratum 2 do show some characteristics of a salt marsh assemblage, especially an increase in the relative abundance of pennate diatoms (*e.g. Navicula spp.*) and a slightly higher species diversity. In general, however, taphonomic and diagenetic factors have either removed or masked any diatom "signature" of a salt marsh environment in the stratigraphic section sampled at Middle Beach. This suggests the need for caution in the use of diatoms in paleoecological reconstruction of salt marsh environments and underscores the efforts of VOS and DEWOLF (1988) to develop criteria for distinguishing autochthonous and allochthonous diatom valves.

The exact nature of the taphonomic and diagenetic factors influencing the composition of the diatom death assemblages at Middle Beach is poorly understood. Most likely, several

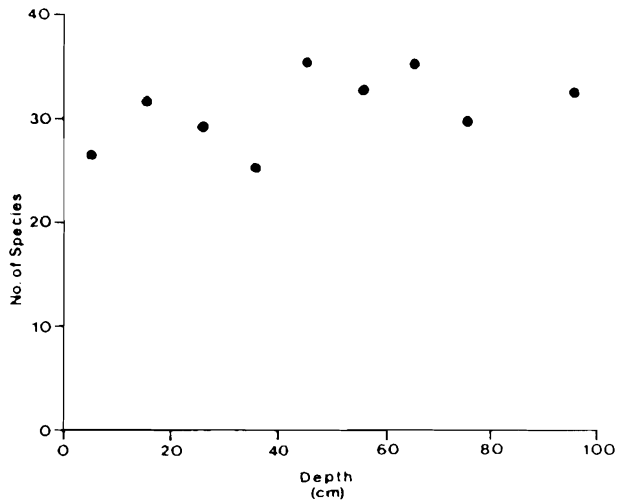


Figure 5. Species diversity vs. depth, Middle Beach section, St. Catherines Island. 500 diatom valves were counted in each sample.

factors have interacted to obscure the original ecological relationships. The average tidal range along the sea islands of Georgia is 2.4 m, the highest of the southeastern U.S. coast (HOWARD and FREY, 1980). Such tidal energies have probably existed since the late Holocene stabilization of sea-level and may have strongly affected the deposition and preservation of diatom valves. The diatom assemblages at Middle Beach exhibit a high degree of valve fragmentation (Figure 6A, B). Abundant, but delicate, diatom taxa may be selectively removed from the assemblages as a result of various types of syndepositional and postdepositional valve transportation (BEYENS and DEYNS, 1982). Fragments of the more delicate diatom valves were observed in abundance in the Middle Beach section. Selective dissolution along increased surface area resulting from valve fragmentation (both biogenic and mechanical) may explain the observed decrease in diatom fragments downsection. GERSONDE and WEFER (1987) suggested that dissolution of diatom valves is enhanced by mechanical breakage.

Fragmentation and dissolution can selectively deplete an assemblage of the weaker and less silicified diatom valves. Tidal action, including transport and alternating wet/dry conditions, certainly hasten these processes. Certain robust forms, such as *Paralia sulcata*,

gradually decrease in abundance towards the base of the Middle Beach section. This may be a result of progressive dissolution through time resulting in a diagenetic modification of the diatom assemblage. This is supported by the downsection absence of the more delicate taxa, such as *Gyrosigma* spp. MIKKELSEN (1980) suggested that diatom species diversity should decrease as dissolution intensity increases. The species diversity of the St. Catherines Middle Beach material is low compared to those salt marsh assemblages described by SULLIVAN (1975, 1977). These low diversity values may be in part due to high rates of dissolution and fragmentation, effectively removing many of the delicate taxa from the assemblage.

The relict salt marsh deposits preserved at Middle Beach accumulated in close proximity to overwash fans which occasionally breached a barrier beach/dune complex. Such an environmental setting invites dilution of *in situ* marsh diatom species by allochthonous valves of littoral species. More open marine planktic and benthic diatom species were abundantly represented throughout the Middle Beach section (Table 1). For example, *Cymatosira belgica*, an offshore littoral diatom (VOS and DE WOLF, 1988), is the most abundant species in the Middle Beach relict marsh deposits, comprising up to 75% of the diatom individuals in the upper third of the section and about 50% at greater

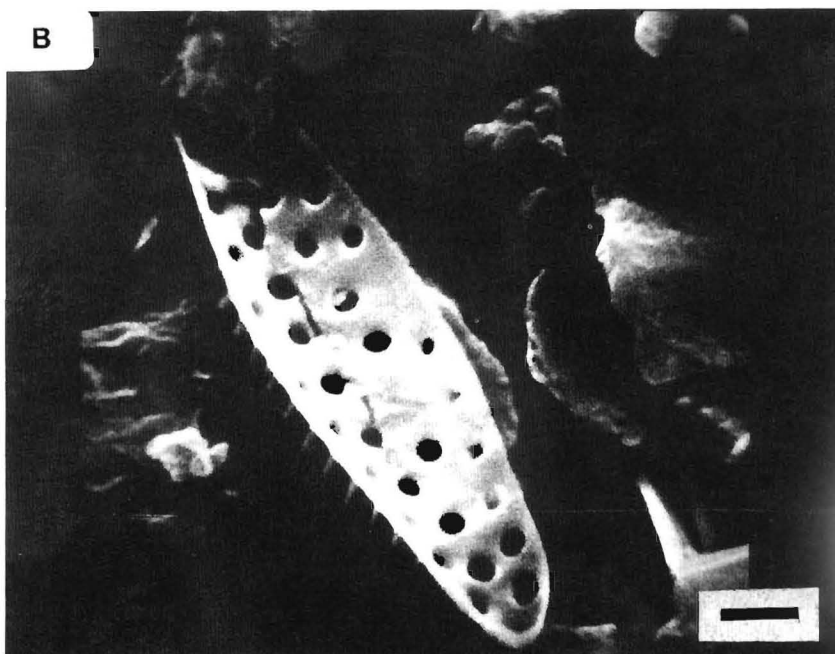
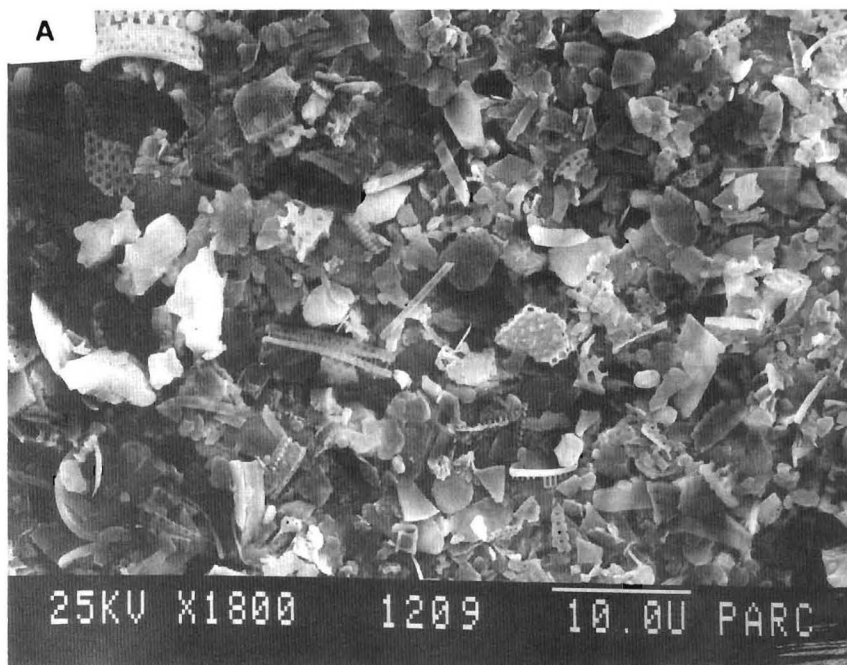


Figure 6. SEM photographs of diatoms from Middle Beach section. (A) Representative diatom "hash" (scale bar = 10 microns). (B) *Cymatosira belgica*, view of single valve (scale bar = 1 micron)

depth. This species, however, is rare in modern salt marsh environments.

The appearance of extinct Miocene species (*Trochosira spinosa* and *Delphineis penelliptica*) in the Middle Beach relict marsh section is not surprising in view of the taphonomic setting of the Georgia Bight. These species have been reported from the coastal plain of Georgia and South Carolina (ABBOTT and ANDREWS, 1979). HOWARD and FREY (1980) indicated that most of the finer grained sediments are transported to the Georgia coast via the Savannah, Ogeechee, and Altamaha rivers. HENDERSON and FREY (1986) have described how scour holes resulting from tidal jets can result in heterochronous mixing of mollusk shells in subtidal shell beds accumulating along the barrier islands of Georgia. Such "stratigraphic leakage" might be even more pronounced in the more easily transported diatom components of fossil assemblages. Many of the diatoms reported in this study have long stratigraphic ranges (from Tertiary to the Recent) and it would be impossible to determine if they had "leaked" from a nearby older sedimentary source or if they were actually living in the area at the time of deposition. Only extinct taxa can be used for determination of stratigraphic "leakage."

Several freshwater diatom species were also reported in the stratigraphic interval. These could have been transported to the site of deposition by wind, surface runoff, and/or tidal currents (bringing in diatoms from some of the freshwater ponds or sloughs on the Island, or even from the coastal plain rivers). Such freshwater components, however, comprise a small portion of the total assemblage.

CONCLUSIONS

The relict marsh deposits of Middle Beach, St. Catherines Island, Georgia, contain diatom assemblages that have been subjected to strong taphonomic and diagenetic overprinting. If paleoenvironmental interpretation and reconstruction of the stratigraphic section at Middle Beach depended only upon the composition of the preserved diatom assemblage, an open marine littoral setting would be erroneously indicated. Fragile salt marsh diatom valves are easily destroyed by fragmentation and/or dissolution, in this case resulting in drastic over-

representation of allochthonous marine littoral species in the preserved assemblages.

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